

ORIGINAL RESEARCH

Spectrophotometric Evaluation of Color Changes of Bleach-shade Resin-based Composites after Staining and Bleaching

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ABSTRACT

Spectrophotometric evaluation of color changes of Bleach-shade resin-based composites after staining and bleaching.

Aim: The aim of this study was to evaluate the color stability of two commercially available bleach-shade resin composites (RC) after exposure to 3 storage solutions and the effect of 3 bleaching agents on the color stability and stain removal from stained RC.

Materials and methods: Two bleach-shade RC were evaluated in this study, including a nanofilled RC, Filtek™ Z350 XT (FZ), and a nanohybrid RC, Tetric® N-Ceram (TC), in the extra-white body (shade) (XWB) and L shades, respectively. Twenty-seven disk-shaped specimens, each measuring 12 mm in diameter and 2 mm in thickness, were prepared for each RC, with a total of 54 specimens. Specimens were randomly allocated into 3 groups of 9 specimens each and immersed in 3 storage solutions (distilled water, tea and coffee) for 7 days period. The 9 specimens in each staining group were further divided into 3 subgroups. Specimens in each subgroup (n = 3) were bleached using one of the bleaching agents (10 and 16% Zoom NiteWhite amorphous calcium phosphate (ACP), and Zoom 2 chairside with light activation) for 5 days period. The specimen colors were measured with spectrophotometer. The measurements were performed on each sample three times at baseline, after staining, and after bleaching. Color was expressed using the commission international de l'Eclairage (CIE) L*a*b* color space. The color differences (ΔE) between the three measurements were calculated and the results were statistically analyzed using Two-way and Three-way analysis of variance (ANOVA) and Tukey's posthoc tests. Level of significance was set at $p < 0.05$.

Results: Tetric® N-ceram materials demonstrated significantly less color change than the FZ and the color change, which was greater after storage in coffee compared to tea, was statistically significant. The bleaching agents significantly influence the color changes of composite specimens. All groups showed (ΔE) values below 3.3 after bleaching, except for 'Zoom 2 chairside' with light activation groups, which is shown clinically unacceptable lighter shade ($\Delta E > 3.3$).

Conclusion: Bleach-shade composites showed significant discoloration ($\Delta E > 3.3$) after being immersed into coffee and tea solutions. Nanofilled composites discolored more than nanohybrid composites, and carbamide peroxide-based bleaching agents were effective in reducing the discoloration to a clinically acceptable value ($\Delta E > 3.3$).

Clinical significance: In this study, after clinically significant discoloration, low concentrations of carbamide peroxide bleaching agents were effective in removing stains and restoring the color of bleach-shade composites to near baseline color.

Keywords: Bleach-shade composites, Staining, Bleaching, Color difference (ΔE), Spectrophotometer.

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INTRODUCTION

Increasing numbers of patients are seeking bleaching treatments because these treatments are safe, relatively non-invasive and predictable.^{1,2} Research has shown that 34% of adults are dissatisfied with their current tooth color,³ and patients often prefer white and shiny teeth instead of a more natural appearance.⁴ This preference has driven advances in bleaching techniques, materials, and devices and has resulted in tooth shades that are whiter than the whitest natural teeth. To restore bleached teeth, manufacturers have begun to produce bleach-shade composites to match the filling materials to the shades of extremely white teeth.

The color stability of bleach-shade resin composites, as with any other esthetic restorative material, is considered to be an important factor in the success of the composites and in patient satisfaction.⁵ However, for resin composites, restorative material discoloration after prolonged exposure to the oral environment is still a major clinical problem and a main cause of restoration replacement.⁶

The amount of discoloration is multifactorial and includes factors that are intrinsic to resin, such as the resin matrix,^{7,8} filler particles,⁹ interface of matrix and fillers,⁸ water sorption,⁸ shade,¹⁰ photoinitiators,¹¹ and degree of conversion of carbon-carbon double bonds.¹² Extrinsic

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factors, such as the absorption and adsorption of colorants from food, beverages, colored mouth rinses, ultraviolet irradiation,⁵ thermocycling,¹³ smoking habits, oral hygiene, and finishing and polishing procedures may also influence extrinsic staining.¹⁴

Many studies have investigated the color stability of resin composites materials upon immersion in coffee, tea and other beverages. Chan et al¹⁵ tested two composites by immersing the specimens in coffee, tea, cola, soy sauce, and distilled water and concluded that coffee and soy sauce produced the greatest discoloration and that the type of material also affected stain resistance. Dietschi et al⁸ reported that erythrosine and coffee caused the greatest color change in the tested composites. The authors concluded that polished surfaces, low water sorption, a high filler-resin ratio, reduced particle size and hardness, and an optimal filler-matrix coupling system helped to improve the composite resistance to discoloration. Gönülo¹⁶ stated that composites with smaller filler sizes did not necessarily show less discoloration. Staining of the resin composites depended on the monomer structure and surface irregularities. Nasim et al⁹ studied the color stability of microfilled, microhybrid, and nanocomposite materials by immersing the specimens in tea, a carbonated drink or distilled water for 7 and 30 days. The authors reported that the microhybrid composite was the most color stable and that the color stability of the resin composites depends on the type of beverage and the composition of the resin composite.

After staining, there are professional methods of removing superficial stains from the resin composites (e.g. bleaching and polishing). Studies have investigated and compared the effect of bleaching on stain removal from composite resins. Garoushi et al¹⁷ stated that both the bleaching and repolishing treatments removed stains. Better results were obtained after repolishing with a polishing paste than bleaching with 40% hydrogen peroxide (Opalescence Boost) once for 40 minutes. Conversely, Türkün and Türkün¹⁸ concluded that bleaching and repolishing were effective in removing the stains. The tested resin composites were reverted to practically the baseline color, and bleaching with 15% hydrogen peroxide (HP) for 1 hour was more effective in restoring color compared to the repolishing procedures. Al-Nahedh¹⁹ et al compared the effectiveness of four stain removal methods using direct resin-based composite. The authors found that bleaching with 10% carbamide peroxide (CP) removed stains from all tested materials and returned the color to clinically acceptable color differences. Villalta et al²⁰ reported that bleaching the stained composite resins with different concentrations of CP (i.e. 16%, 18% and 35%) completely removed the stains from the tested materials.

Studies have also investigated the effect of bleaching agents on the color, surface roughness and topography of resin composites. Regarding the influence of various bleaching agents on the color of composite resins, Monaghan et al^{21,22} found no significant differences in the composite color after exposure to 10% CP, while exposure to 30% HP with infrared light produced significant color changes in some composite resin restorative materials. The authors also stated that this method might be a viable technique to lighten the shade of some darkened or stained tooth-colored restorations. Canay et al²³ studied the effect of both 10% CP and 10% HP on resin composites and found that a clinically unacceptable change was produced by 10% HP, with a color change (ΔE) for a hybrid composite ranging from 3.41 to 4.51.

Bleach-shade resin composites have been recently introduced into the market. The color stability of these materials and effects of staining and bleaching on color changes of this material have not been widely investigated. The purpose of this study was to evaluate the color stability of two commercially available bleach-shade resin composites after exposure to three immersion solutions (coffee, tea and distilled water) and the effect of three bleaching agents (i.e. 10% CP, 16% CP and 25% HP-light activated bleach) on the color stability and stain removal from stained resin composites. The major null hypothesis is that there is no difference in the color stability of composites after immersion in solutions and bleaching procedures.

MATERIALS AND METHODS

Sample Preparation

Two bleach-shade composite resins were evaluated in this study, including a nanofilled resin composite, FiltekTM Z350 XT (3M ESPE, St. Paul, MN, USA), and a nanohybrid resin composite, Tetric[®] N-Ceram (Ivoclar/Vivadent AG, Schaan, Liechtenstein), in the extra-white body (shade) (XWB) and L shades, respectively (Table 1).

The 27 disk-shaped specimens, each measuring 12 mm in diameter and 2 mm in thickness, were prepared for each composite resin, with a total of 54 specimens. The samples were prepared by condensing the material into a polytetrafluoroethylene ring (12 mm in diameter and 2 mm in thickness) closed from the bottom with glass slides and a polyester strip (Mylar strip; SS White Co, Philadelphia, PA, USA). A nylon thread was incorporated into the specimen to ensure that the specimen could be suspended in the storage solutions.

The ring was filled with the composite resin and a second polyester strip was placed on the top of the filled mold. A glass slide was pressed against the upper polyester strip to extrude the excess composite resin and to form a flat sur-

Table 1: Resin composites used

Brand	Shade	Matrix and Photo-initiator	Filler (% by volume)	Manufacturer	Lot no.
Filtek™ Z350 XT	XWB	Bis-GMA, Bis-EMA, UDMA, TEGDMA, CQ (468 nm)	Silica (20 nm) Zirconia and silica (0.6-1.4 µm) Agglomerated 59.5%	3M ESPE, St Paul, MN, USA	N427930
Tetric® N-Ceram	L	Bis-GMA, Bis-EMA, UDMA Lucirin TPO3 (375-410 nm) CQ (468 nm)	Barium glass, ytterbium trifluoride, Ba-Al- fluorosilicate glass, silica highly dispersed, mixed oxide and prepolymers (40 nm and 3,000 nm) 55-57%	Ivoclar/ Vivadent AG, Schaan, Liechtenstein	S09547

Bis-GMA: Bisphenol-A-glycidyl dimethacrylate; UDMA: Urethane dimethacrylate; Bis-EMA: Bisphenol A ethoxylate dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate; CQ: Camphorquinone

face. The material was then light-cured from the top with the halogen curing light QHL75 Curing Light (Dentsply Caulk, Milford, DE, USA) for 40 seconds. The top surfaces and sides of all specimens were then polished with fine and superfine fine (24 µm) and superfine (8 µm) aluminum oxide polishing disks (Sof-lex, 3M ESPE, St Paul, MN, USA) with a slow-speed hand piece under dry conditions. Then, the specimens were stored in distilled water for 24 hours in an incubator at 37°C. Color measurements were taken with a spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Bad Säckingen, Germany) expressed as Commission Internationale d'Eclairage (CIE) L*a*b* coordinates and recorded as baseline.

Staining Process

For each composite, specimens were randomly allocated into 3 groups (n = 9), according to the storage solutions (distilled water, tea and coffee). Every specimen was immersed in a vial containing the solution and kept in an incubator at 55°C in the coffee and tea groups and at 37°C in the distilled water group over a 7-day test period. The tea solution was prepared by immersing two prefabricated black tea bags 2.0 g (Lipton, Yellow Label, Unilever United Arab Emirate) into 500 ml of freshly boiled distilled water for 10 minutes, and the coffee solution was prepared by dissolving 3.6 gm (two sachets, 1.8 gm each) of coffee powder (Nescafe Red Mug, Nestle Brazil, Araras, Brazil) in 500 ml of freshly boiled distilled water. Both solutions were cooled to 55°C before use and the solutions were renewed daily. After storage, the specimens were rinsed and dried, and the color measurements were taken with the spectrophotometer and recorded as stained.

Bleaching Process

Three bleaching agents were used in this study (Table 2). The 9 specimens in each staining group were further divided into 3 subgroups. Specimens in each subgroup (n = 3) were bleached using one of the bleaching agents. The bleaching agents were painted on the top surface of the specimen, according to the manufacturers' instructions. Home bleaching 10% (CP10) or 16% (CP16) carbamide peroxide [Zoom NiteWhite ACP, Discus Dental, Limited liability company (LLC), Los Angeles, CA, USA] agents were applied at 37°C for 4 hours per day for 5 days to simulate the home bleaching process. For in-office bleaching, 25% HP gel (Zoom 2, Discus Dental, Dental, LLC, Los Angeles, CA, USA) was applied to the samples, and a light (Zoom 2, Discus Dental, CA, USA) with a wavelength between 400 and 505 nm was activated (i.e. two 15 min cycles), and the whitening gel was changed after each cycle. Two sessions were carried out with a 5-day interval.

After bleaching, the specimens were rinsed with tap water for 1 minute to remove the bleaching agents, dried, and stored in distilled water at 37°C until the next application. On the 5th day, the specimens were rinsed and dried prior to the color measurements (with a spectrophotometer) and recorded as bleached.

Color Assessment and Color Difference Calculations (ΔE)

The specimen colors were measured with a Vita Easyshade spectrophotometer. This device is a contact type spectrophotometer, with D65 illumination and a geometric 2°/0°

Table 2: Bleaching systems used

Brand	Active ingredient	Manufacturer	Lot no.
Zoom NiteWhite ACP (10%)	10% carbamide peroxide	Discuss Dental, LLC Los Angeles, USA	13141007
Zoom NiteWhite ACP (16%)	16% carbamide peroxide	Discuss Dental, LLC Los Angeles, USA	13141009
Zoom2	25% hydrogen peroxide	Discuss Dental, LLC Los Angeles, USA	13127010

ACP: Amorphous calcium phosphate

observer curve. The instrument was calibrated before use on each sample. The measurements were performed on each sample against a neutral gray background (X-rite ColorChecker Passport, X-rite Inc) by a single operator (three times at baseline, after staining and after bleaching). Color was expressed using the CIE L*a*b* color space. The color differences (ΔE) between the three measurements were calculated as follows:

$$\Delta E = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - a_1^*)^2}$$

Where L* is lightness, a* is green-red (-a* = green; +a* = red) and b* is blue-yellow (-b* = blue; +b* = yellow). In this study, we considered a color difference ($\Delta E \geq 3.3$) to be clinically unacceptable.²⁰

STATISTICAL ANALYSIS

After verifying the normality of the results with the Shapiro-Wilk test, a two-way ANOVA was used to evaluate the effects of brand and storage solution on color change after staining (ΔE_1 between baseline and stained) and to evaluate the possibility of interaction between the two factors. Three-way ANOVAs were performed to compare the effects of brand, storage solution, and bleaching agent on color change after bleaching (ΔE_2 between baseline and bleached). Tukey's post hoc test was used for pair-wise comparisons between the means when the ANOVA tests were significant. The level of significance was set at $p < 0.05$. Statistical analysis was performed with statistical SPSS 20.0 software (Statistical Package for Scientific Studies Inc. Chicago, IL, USA).

RESULTS

After Immersion (ΔE_1)

The means and standard deviations of color differences of each resin composite are given for each storage solution (Table 3). Statistical analysis (2-way ANOVA) revealed the significant effects of the discoloration of the restorative material brand and storage solution, as well as their interactions ($p < 0.001$) on ΔE_1 (Table 4).

Among the storage solutions for both the resin composite restorative material brands, the specimens stored in distilled water produced no perceptible discoloration ($\Delta E \leq 1$), and the specimens stored in coffee and tea demonstrated clinically unacceptable color changes ($\Delta E \geq 3.3$) (Figs 1 and 2). Tukey's post hoc test for all pairs of storage solutions identified significant differences between the solutions ($p < 0.001$), and the color change, which was greater after storage in coffee compared to tea, was statistically significant. The change was greater in both solutions compared to the water solution.

Among the restorative material brands, significant differences were observed between the FZ and TC materials

($p < 0.001$) Moreover, the TC materials demonstrated significantly less color change than the Filtek™ Z350 XT (FZ). The significant interactions between storage solutions and the composite resin material showed that the discoloration of the different composite resin materials differs greatly depending on the storage solution.

After Bleaching (ΔE_2)

The means and standard deviations of the color differences in each resin composite in each immersion solution and bleaching procedures are shown in (Table 5, Figs 1 and 2).

Table 3: Mean (SD) of color change (ΔE_1)

Composite	Solution	Mean (SD)
Filtek™ Z350 XT	Coffee	15.87* (0.45)
	Tea	12.52* (0.29)
	Distilled Water	0.39 (0.22)
Tetric® N-Ceram	Coffee	11.83* (0.49)
	Tea	8.87* (0.34)
	Distilled Water	0.91 (0.36)

*Indicates that the color is clinically unacceptable; SD: Standard deviation

Table 4: Two-way analysis of variance for resin composites and immersion solutions

Source	df	Sum of Squares	Mean Square	F	p
Material	1	76	76	553	<0.001
Solution	2	1710	855	6148	<0.001
Material × Solution	2	57	28	205	<0.001

$p < 0.05$ means statistically significant difference

Table 5: Mean (SD) of color change (ΔE_2)

Composite	Solution	Material	Mean (SD)
Filtek™ Z350 XT	Coffee	CP10%	2.92 (0.28)
		CP16%	2.33 (0.10)
		HP25%	4.03* (0.23)
	Tea	CP10%	2.52 (0.19)
		CP16%	2.16 (0.28)
		HP25%	4.70* (0.32)
	Distilled water	CP10%	0.92 (0.10)
		CP16%	1.28 (0.14)
		HP25%	5.19* (0.26)
Tetric® N-Ceram	Coffee	CP10%	2.20 (0.44)
		CP16%	1.36 (0.24)
		HP25%	5.26* (0.30)
	Tea	CP10%	0.73 (0.25)
		CP16%	1.43 (0.24)
		HP25%	5.49* (0.45)
	Distilled water	CP10%	2.34 (0.28)
		CP16%	2.27 (0.22)
		HP25%	5.25* (0.27)

*Indicates that the color is clinically unacceptable; SD: Standard deviation

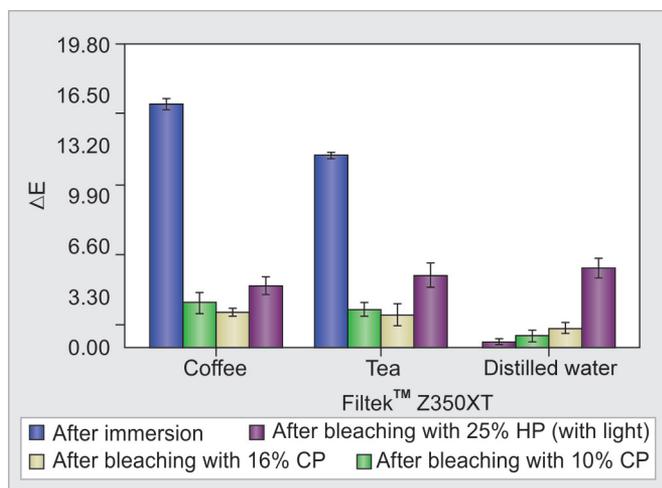


Fig. 1: Mean and standard deviations color differences (ΔE_1 and ΔE_2) for Filtek™ Z350XT

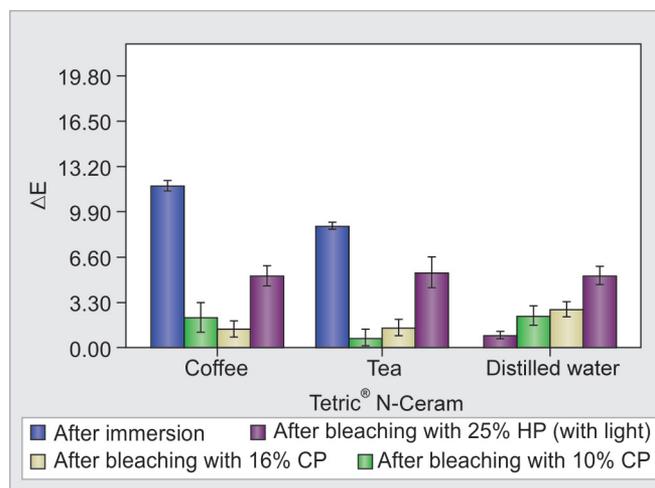


Fig. 2: Mean and standard deviations color differences (ΔE_1 and ΔE_2) for Tetric® N-Ceram

The statistical analysis (3-way ANOVA) showed significant differences among the bleaching procedures ($p < 0.001$) and the interaction of the factors ($p < 0.001$). However, there is no significant difference between the materials ($p = 0.247$) and storage solutions ($p = 0.143$).

The results of the statistical analysis showed that the bleaching agents significantly influence ($p < 0.001$) the color changes of composite specimens. Tukey's tests for all pairs identified no significant difference between the 10 and 16% CP bleaching groups ($p = 0.867$), while these groups were significantly different ($p < 0.001$) from the 25% HP (with light) groups.

All groups showed (ΔE_2) values below 3.3 after bleaching, except for 25% HP (with light) groups. Analyses of the contribution of each individual CIE parameters L^* , a^* and b^* were conducted for these groups. The greater color differences in the composites are mainly because of a decrease in the b^* coordinate. The decrease in the b^* coordinate is shown as a decrease in the yellow color. The change in a^* was relatively minor and this shift did not contribute significantly to the resultant ΔE^* . The L^* coordinate change was generally a higher value, which is shown as a lighter shade (Fig. 3).

DISCUSSION

In the present study, the color stability of two bleaching shade composites was assessed after staining with common beverages and then bleaching by either two concentrations carbamide peroxide-based home bleaching or hydrogen peroxide base in-office light activated bleaching. Both resin composites tested showed clinically unacceptable color changes when immersed in both staining solutions (coffee and tea). All specimens exceeded the critical threshold ($\Delta E \geq 3.3$), and the color change in the composite was brand- and

storage-solution dependent, which is consistent with reports in the literature.²⁴⁻²⁸

The color of the nanohybrid resin composite (TC) was the least affected by the immersion, whereas the nanofilled resin composite (FZ) was the most prone to color change. There are two explanations for this finding. First, the color of the FZ was lighter than the TC ($\Delta L^* \approx 4$ units), and there is a correlation between color and discoloration in the resin composites. Lighter materials discolor more markedly than darker ones.^{7,29} This fact also explains the higher ΔE_1 reported in this study than previous reports.^{7,20} The high ΔE_1 in this study could also be attributed to the high temperature employed in the storage solution ($55^\circ\text{C} \pm 1$), which likely heated the surface of the material, thus affecting the staining process.²⁶ Second, the resin matrix used in the materials plays an important role in stain susceptibility.³⁰ Water uptake in the Bis-GMA-based resins increased from 3 to 6% as the proportions of TEGDMA (triethylene glycol dimethacrylate) increased from 0 to 1%.³¹ FZ and TC

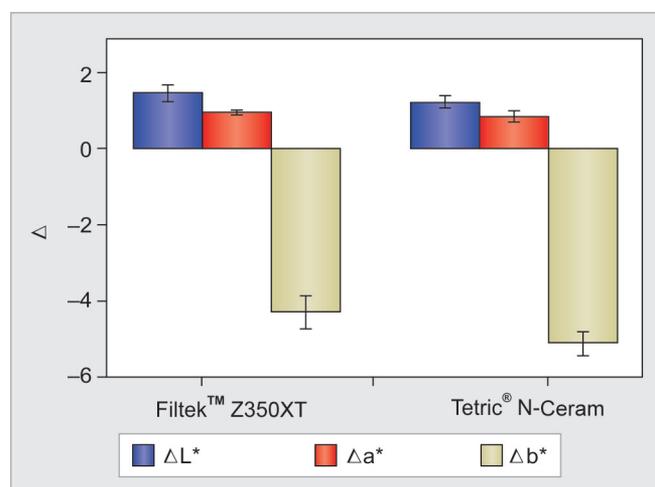


Fig. 3: Mean and Standard deviation of differences from baseline in CIE color coordinates (ΔL^* , Δb^* , Δa^*) After bleaching with 25% HP (with Light)

have similar resin matrix compositions, with the addition of TEGDMA in the FZ resin matrix, So FZ might absorb staining substances along with water more easily, which explains why the FZ has a greater discoloration.

Regarding storage solutions in this study, both composite resins demonstrated unacceptable color changes when stored in coffee and tea, with a greater color change in the coffee compared to tea. While composite samples immersed in distilled water demonstrated imperceptible color changes ($\Delta E \leq 1$), which is consistent with previous reports,^{9,15,20} water sorption alone did not alter the composite colors to a considerable extent. The greater color change in coffee may be because of both absorption and adsorption of the yellow low-polarity stains, which can penetrate deeper into the polymer matrices of the resin composites.³² Yellow stains from tea have a high polarity; they precipitate on the surface through adsorption only and are first eluted after rinsing with water because of the stain's mobile and high polarity phases.¹² This finding has been confirmed in several studies.^{8,20,33} One study has demonstrated that tea causes a greater color change than coffee. However, the type of tea used and how the storage solutions are prepared were not detailed in the study.³⁴

After bleaching with 10 and 16% CP, the color of the stained specimens changed to a clinically acceptable color to baseline ($\Delta E \leq 3.3$) even after significant discoloration because of staining, particularly in the FZ stored in the coffee solution. These results are consistent with previous studies that evaluated the effects of carbamide peroxide – based bleaching agents on resin composites stain removal. Al-Nadedh et al¹⁹ reported that bleaching with 10% CP for four hours daily for 2 weeks was superior to both polishing and 38% hydrogen peroxide-based in-office bleaching procedures for stain removal and can effectively remove stains from all tested materials and return them to a clinically acceptable color. Villalta et al²⁰ studied the effect of different concentrations of CP (16, 18 and 35%) on stain removal from resin composites. The results of their study showed how effective the bleaching agents were in removing the exterior staining of dental resin composites and virtually reversed the composite color to baseline ($\Delta E \leq 3.3$).

For light-activated 25% HP, bleaching removed stains from the composite samples and bleached the composite samples to a brighter color. The ΔE_2 of composite resins of all 25% HP bleaching samples exceeded the clinically acceptable color change of $\Delta E \geq 3.3$ from the baseline color. This change is mainly because of the decrease in the b^* coordinate. A decrease in the b^* coordinate reflects a shift to a more blue color range (farther away from the yellow color range). The change in a^* was relatively minor, and this shift did not significantly contribute to the resultant ΔE . The L^*

coordinate change was generally a higher value and a lighter shade. Regarding stain removal, these results appeared to contradict Al-Nadedh et al¹⁹ who reported that 38% HP did not remove stains from two of three resin composites used in his study. The authors explain this by noted the short, total application time of the in-office bleaching agents compared to home bleaching agents used in the study. A study by Garoushi et al¹⁷ stated that bleaching with 40% HP for 40 minutes reduced the ΔE of the discolored samples but did not completely remove the stains. Better results were obtained by repolishing the specimens with 0.1 μm Alumina polishing paste. This study results agree with Türkün and Türkün,¹⁸ who showed that using bleaching agents with 15% active HP was effective in removing superficial and deeply penetrated stains from the resin composites samples.

Regarding the ability of in-office HP bleaching agent to bleach composite materials, we found the same results as Monaghan et al,²² who reported that in-office bleaching significantly affected the colors of different composites. The authors reported ΔE values >3.3 . Their bleaching protocol consisted of a pre-etching procedure using phosphoric acid, followed by four cycles (30 min each) of bleaching using 30% HP and infrared light activation. Conversely, Hubbezoglu et al³⁵ observed that the color changes in both microfilled and microhybrid resins after bleaching with 35% HP for a total of 30 minutes were $\Delta E \leq 3.3$, but their bleaching protocol did not use light. Hafez et al³⁶ also found that using a light in the bleaching process increases the effect of bleaching on the composite, and they suggested that light-activated bleaching had a greater whitening effect on stained composites and might be more beneficial in bleaching restorative resins than in bleaching tooth structures.

Using CP-based bleaching agents for resin composite stain removal will raise some esthetic concerns, including possible color mismatches between the restored resin composite and the surrounding tooth structure. CP can remove stains from the composite, but cannot bleach the composite; however, CP can effectively bleach teeth.³⁷ If we consider that bleached teeth become darker with time, as reported by Grobler et al,³⁸ there is a 13.7 and 20.2% decrease in the ΔE values 6 and 14 months after bleaching, respectively, and CP effectiveness on tooth color change decreases as the bleaching period decreases, and the tooth color become Lighter.³⁹ Consequently rebleaching with CP, using a short treatment period, will reestablish the color match between the restoration and the tooth structure, due to its ability to return the tooth color to baseline (or to the color after the first bleach), in addition to stain removal from the resin composite restoration.

Using CP-based bleaching agents for resin composite stain removal may also increase the surface roughness and

so stain susceptibility of resin composites. Using scanning electron microscopy (SEM), Polydorou et al⁴⁰ concluded that CP bleaching did not cause major surface texture changes on the polished surfaces of Resin composites. Turker and Biskin,⁴¹ and Moraes et al⁴² reported no significant surface roughness alterations because of CP bleaching. Other studies^{43,44} have reported conflicting results that show alterations on the surface morphology of resin composites because of bleaching. However, because the surface roughness values did not exceed 0.2 μm , the results of these studies were not clinically significant.⁴⁵

In this study, after clinically significant discoloration, low concentrations of CP bleaching agents were effective in removing stains and restoring the color of bleach-shade composites to near baseline color. Further investigation with a larger sample size and studies using teeth restored with resin composites are needed to gain more insight into the clinical relevance and color match between tooth structure and bleach-shade composites after bleaching.

CONCLUSION

Bleach-shade composites showed significant discoloration ($\Delta E > 3.3$) after being immersed into coffee and tea solutions. Nanofilled composites discolored more than nano-hybrid composites, and CP-based home-bleaching agents were effective in reducing the discoloration to a clinically acceptable value ($\Delta E > 3.3$). High concentrations of light-activated HP-based bleaching agents remove stains and bleach resin composites to a lighter shade with clinically unacceptable color differences from baseline.

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